

# Report on NASA-Sponsored Activities related to Venera D

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- During the calendar year 2017, NASA with the support of NASA Centers JPL and the Venus Exploration Assessment group (VEXAG) has initiated a number of activities that are relevant to the collaboration on Venera D
  - Strategy for Venus Exploration – developed by VEXAG
  - HOTTech technology development program
  - Aerial Platforms Study
  - Venus Bridge Study
  - Venera D Engineering Support
- The objectives of each of these activities and their relationship to one another and to the Venera JSDT are now outlined



# VEXAG Goals and Objectives for Venus Exploration



## Atmosphere

- How did the atmosphere form and evolve?
- What controls the atmospheric super-rotation and greenhouse?
- What is the impact of clouds on climate and habitability?

## Surface & Interior

- How is heat released from the interior and has the global geodynamic style changed with time?
- What are the contemporary rates of volcanism & tectonism?
- How did Venus differentiate and evolve over time?

## System Interactions & Water

- Was surface water ever present?
- What role has the greenhouse had on climate history?
- How have the interior, surface, and atmosphere interacted as a coupled system over time?



# Strategy for Venus Exploration \*



- Provides a vision for Venus exploration for the next 30+ years;
  - Science objectives
  - Flyby and orbiter missions
  - Aerial exploration
  - Surface exploration and sample return
- Identifies the unique challenges and opportunities for exploring Venus resulting from the dense atmosphere and high surface temperatures
- Defines the set of high priority technologies for achieving the exploration goals including
  - New thermal protection systems (TPS).
  - High-temperature subsystems and components for long-duration (months) surface operations.
  - Aerial platforms for similar long-duration operations in the atmosphere
  - Deep-space optical communications

\* VEXAG presentation at Planetary Science Visions  
2050 meeting February 2017

*Pre-Decisional Information -- For Planning and Discussion Purposes Only*



# High Operating Temperature Technology (HOTTech)



- The Hot Operating Temperature Technology (HOTTech) program supports the advanced development of technologies for the robotic exploration of high-temperature environments, such as the Venus surface, Mercury, or the deep atmosphere of Gas Giants.
  - The goal of the program is to develop and mature technologies that will enable, significantly enhance, or reduce technical risk for in-situ missions to high-temperature environments (500 Celsius or higher).
  - HOTTech is limited to high temperature electrical and electronic systems that could be needed for potentially extended in-situ missions to such environments.
- The HOTTech solicitation was announced in August 2016 with proposals due in December 2017
- Selections were made in the spring of 2017 and development is now underway on a range of technologies. These are R&TD efforts and do not include flight hardware

**The Glenn Extreme Environment Rig (GEER) will play a key role in evaluation many of these technologies**

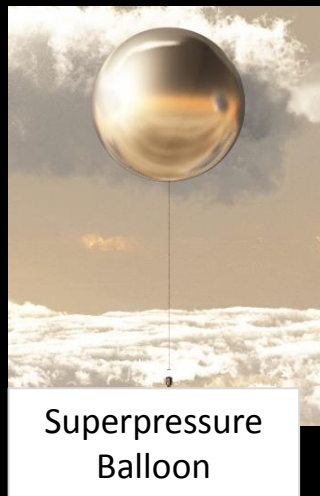


# Venus Aerial Platforms Study



- Venus Exploration Roadmap identified Aerial Platforms as a key capability in the exploration of Venus and NASA Planetary Science Division formed a study team to formulate a plan for the agency
- First study team meeting – May 30 to June 2 2017
  - Scientific opportunities offered by aerial platforms at Venus,
  - Environments that aerial platforms must contend with
  - Capabilities of alternative aerial platform technologies
- Second Study Team Meeting Nov 28 to Dec 1, 2017 (**U.S. Only?**)
  - Feasibility of options identified in the first meeting
  - Maturity of extreme environment technologies
  - Mission design and architecture
- Reporting Phase – target completion Feb 2018

# VEXAG - Aerial Mobility Roadmap



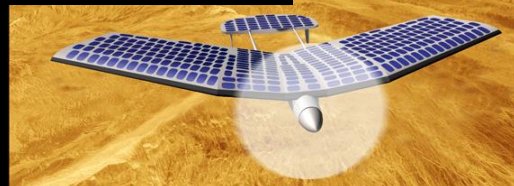
Superpressure Balloon

Lateral mobility

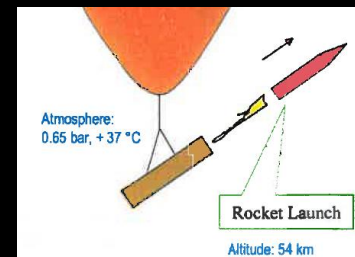
Hybrid Airship (VAMP)



Solar Airplane

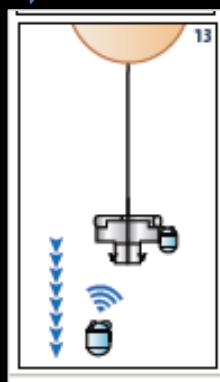


Surface and Cloud Particle Sample Return



In Situ Sample Analysis @ 54km)

DEPLOY PROBES AND SONDES



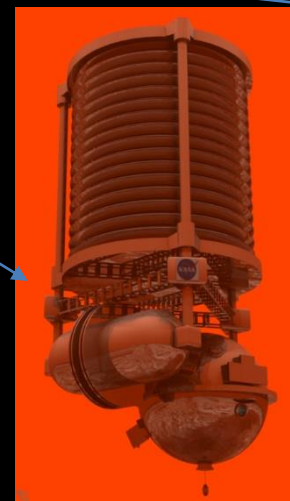
Altitude Control

AM-SAC Aerostat



Near Term

Mid Term



Venus Mobile Explorer

Dual Balloon concept for raising Venus Surface Samples to 55 km altitude

Far Term





# Aerial Platforms - Science Assessment



- The benefits of varying altitude is a strong common thread running through all three science areas
  - Uncontrolled cycling over an altitude range satisfies some science goals
  - Control of when the vehicle moves up or down is important in others
  - Accurate positional knowledge is important in both cases
- Horizontal position control does not appear to be as critical
  - Altitude control will enable moving in and out of different air masses
  - Fine positional control not a high priority at this time
  - Adequate positional knowledge both desirable and achievable
  - Positional control sufficient to overcome meridional drift would be desirable
- Probes that operate in the lower 10 km of the atmosphere are also a priority
  - Short life time probes can carry out the most complex measurements
  - Long lived probes will require development and sensors will initially be limited in what they can measure to pressure, temperature, acceleration, gas composition.





# Venus Low Cost Missions (1 of 2)



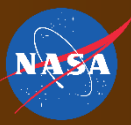
- VEXAG has been directed by NASA's Science Mission Directorate Associate Administrator to determine if useful Venus exploration can be performed within a \$200M cost cap a concept termed **VenusBridge**.
- Specifically, VEXAG will determine if one or more small missions can perform important science investigations, as defined in VEXAG Goals, Objectives, and Investigations (GOI: [www.lpi.usra.edu/vexag/reports/GOI-2016.pdf](http://www.lpi.usra.edu/vexag/reports/GOI-2016.pdf)) with launch dates in the early-to-mid 2020s
- The **VEXAG Venus Bridge Focus Group** was established to develop the Venus Bridge concept and determine if it is feasible
- The NASA Planetary Science Division is also funding 19 studies of low cost missions (up to \$100M) under the Planetary Science Deep Space Small Satellite (PSDS3) program. Four of the studies are targeted at Venus



- A JPL A-team (Architectural) study of potential Venus Bridge concepts was conducted in May 2017. This led to a set of concepts including
  - Small sat orbiters
  - Probes – skimmers and deep probes
  - Balloons
  - Long duration landers
- A second phase of the study is now underway focusing on point designs
  - Orbiter and long duration lander (NASA Glenn Research Center)
  - Orbiter with atmospheric element (JPL)
- The four PSDS3 Venus concept studies are:
  - Cubesat for UltraViolet Venus Exploration (CUVE)
  - Venus Airglow Measurement Orbiter for Seismicity (VAMOS)
  - Cupid's Arrow
  - Long Life Insitu Solar System Explorer (LISSE)



# Relationship of NASA Sponsored Venus Activities to Venera D



	Long lived Landers	Venus Aerial Platforms	Small Satellites
HOT Technology program	H	M	
GEAR Facility	H	M	
Venus Aerial Platforms Study		H	
Venus Bridge Study	H	H	H
<b>Venera D Engineering Support</b>	<b>H</b>	<b>H</b>	<b>H</b>

H= High Relevance

M= Moderate relevance



# Venera D Engineering Support



- This is a new activity begun at JPL in July 2017 to provide a technical and engineering support effort to complement the efforts of U.S. members of the JSDT
- Initial objectives of this effort are
  - Perform a comprehensive assessment of various possible U.S. contributed elements including technical maturity;
  - Assess the plans for accommodating potential US contribution(s) including resource requirements, and deployment strategies
  - Assess overall system risks for the U.S. contributed element(s) relative to the overall Venera-D architecture
  - Evaluate telecommunications relay options compatible with the return of science data from surface landers and aerial vehicles
  - Interact with the engineering team at Lavochkin to work interface issues for potential U.S. contributed elements



# Venus Sponsored Activities and Venera D Schedule



Activity	Calendar Year			
	2016	2017	2018	2019
Venera D Study				
JSDT Report		◆		
Mission Design			◆	
Payload Definition			◆	
Contributed Element			◆	
Risk Assessment			◆	
Final Report				◆
HOT Tech program	◆	◆		
Venus Aerial Platforms		◆	◆	
Venus Bridge Study		◆	◆	
Venera D Engineering support		◆	◆	



# Summary



- NASA is sponsoring a number of technology development, mission studies and planning activities that are related to Venus
- The activities involving aerial platforms including balloons, long duration landers, high temperature technologies and small satellites are relevant to potential U.S. contributed elements for the Venera D mission
- NASA has established a Venera D engineering support activity to ensure that the results of these activities can be channeled into the more detailed definition of Venera D contributed elements during the next two years.
- NASA will continue to explore synergies between various programs that can be beneficial to the Russia- U.S. collaboration on Venera D